



## Computational fluid dynamic analysis of concentration polarization and water flux optimization in spiral wound modules

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# Computational fluid dynamics analysis of concentration polarization and water flux optimization in spiral wound modules

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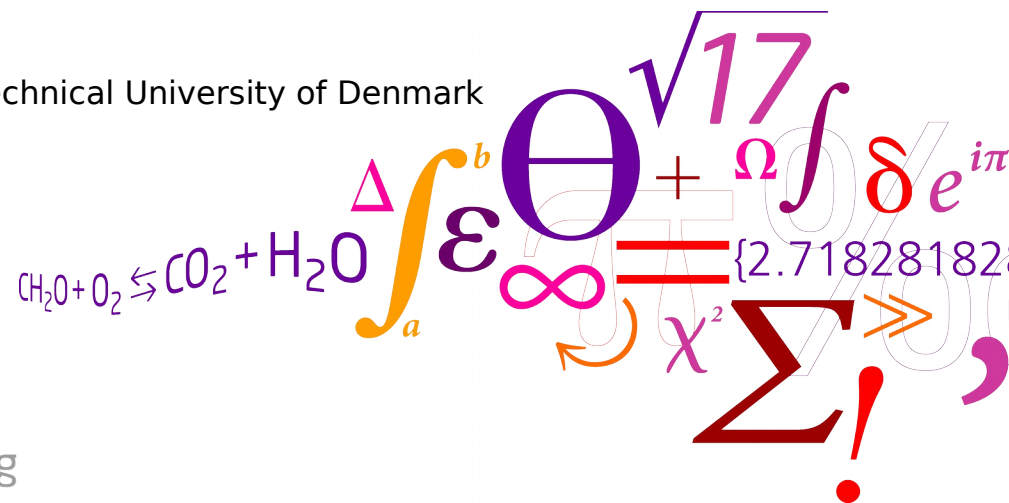
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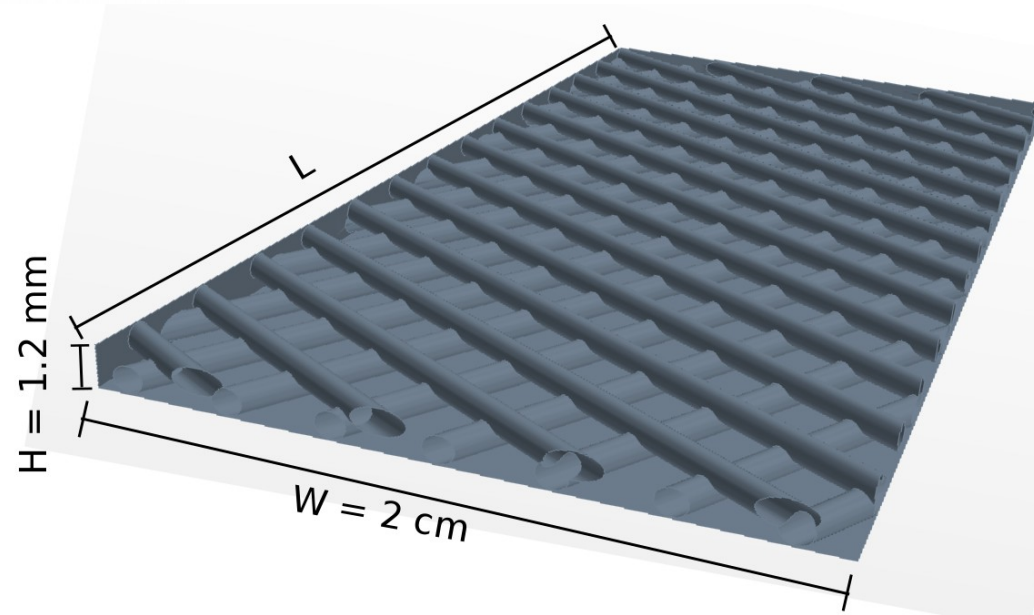
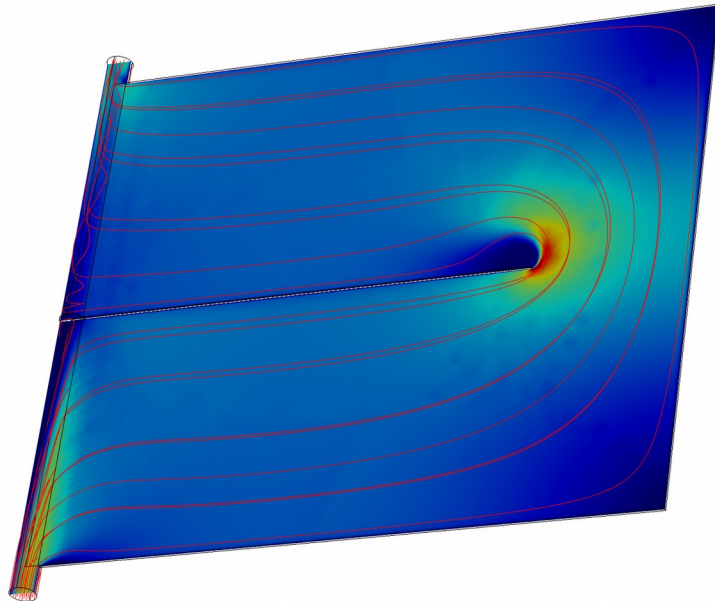
(b) Aquaporin A/S

**DTU Environment**  
Department of Environmental Engineering

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# Investigation of the number of envelopes for FO-SWM

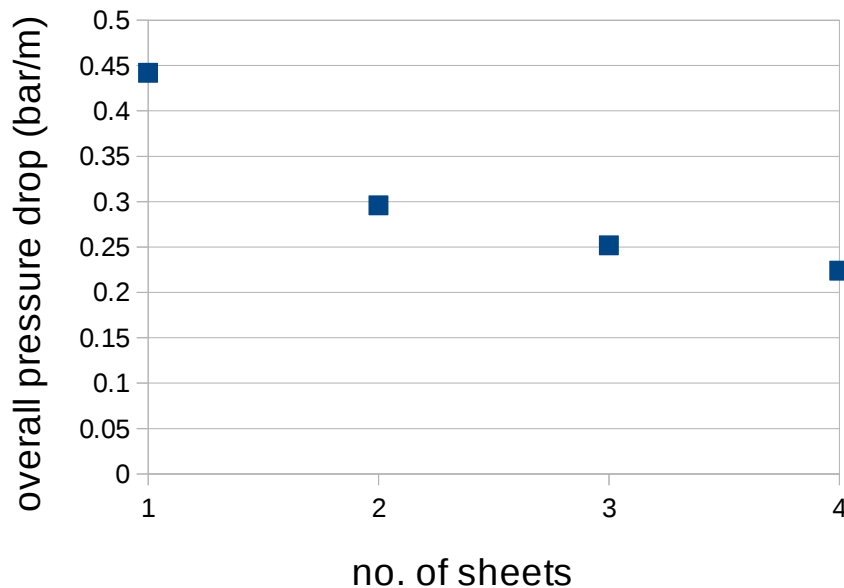


- A baffle inside the inner tube and the envelopes, forces the respective solution to flow around the baffle tip.
- The inhomogeneous flow field causes severe ECP.

- Investigation of pressure drop in FO-SWM configuration
- Spacer similar to Conwed '46 Mils' RO spacer:  $D = 2.55\text{mm}$ ;  $H = 1.17\text{mm}$

# Investigation of the number of envelopes for FO-SWM

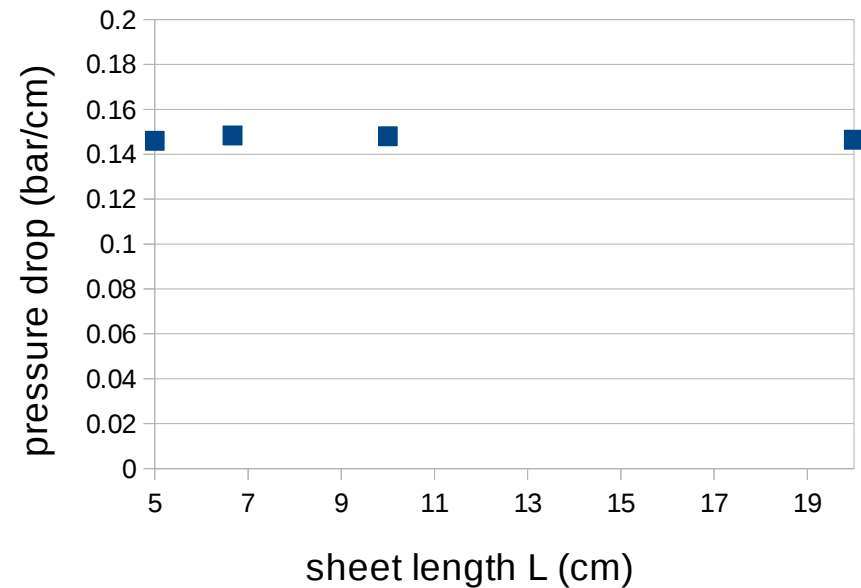
1. The overall pressure drop get smaller with the number of sheets, due to the reduced cross flow velocity.



1. Fixed feed flow rate  $1.26 \text{ e-2 m}^3/\text{s}$

$$\frac{\Delta p}{L} = \mathcal{O}(U_{cross}^2)$$

2. The pressure drop along a sheet is constant.

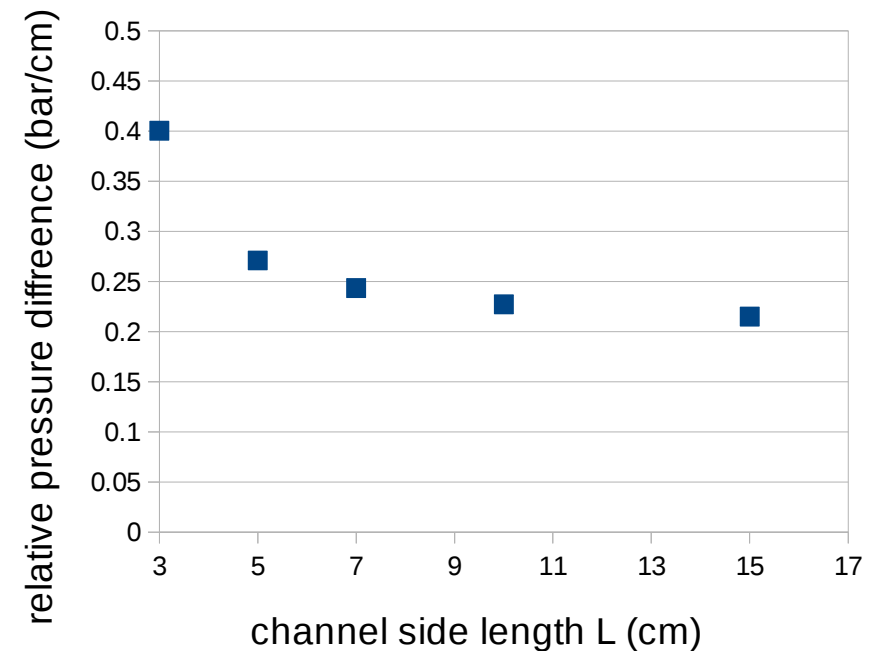
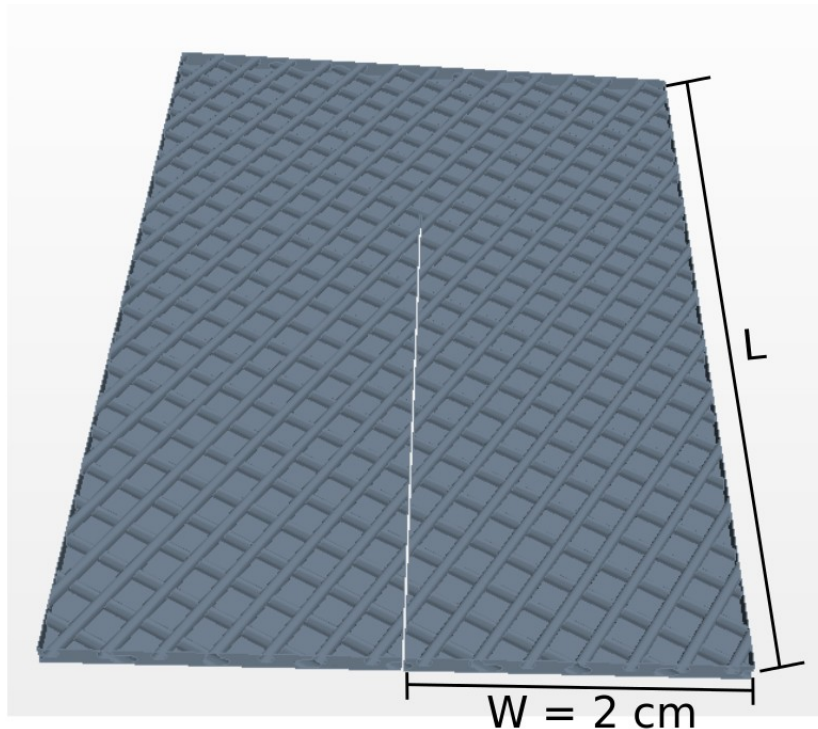


2. Fixed cross flow velocity  $10 \text{ cm/s}$

$$\Delta p \sim L$$

# Investigation of the number of envelopes for FO-SWM

1. While keeping the cross flow velocity constant, the pressure difference divided by the side length (relative pressure difference) is not constant.



Fixed cross flow velocity 10 cm/s

➔ The number of membrane envelopes in FO-SWM matters.

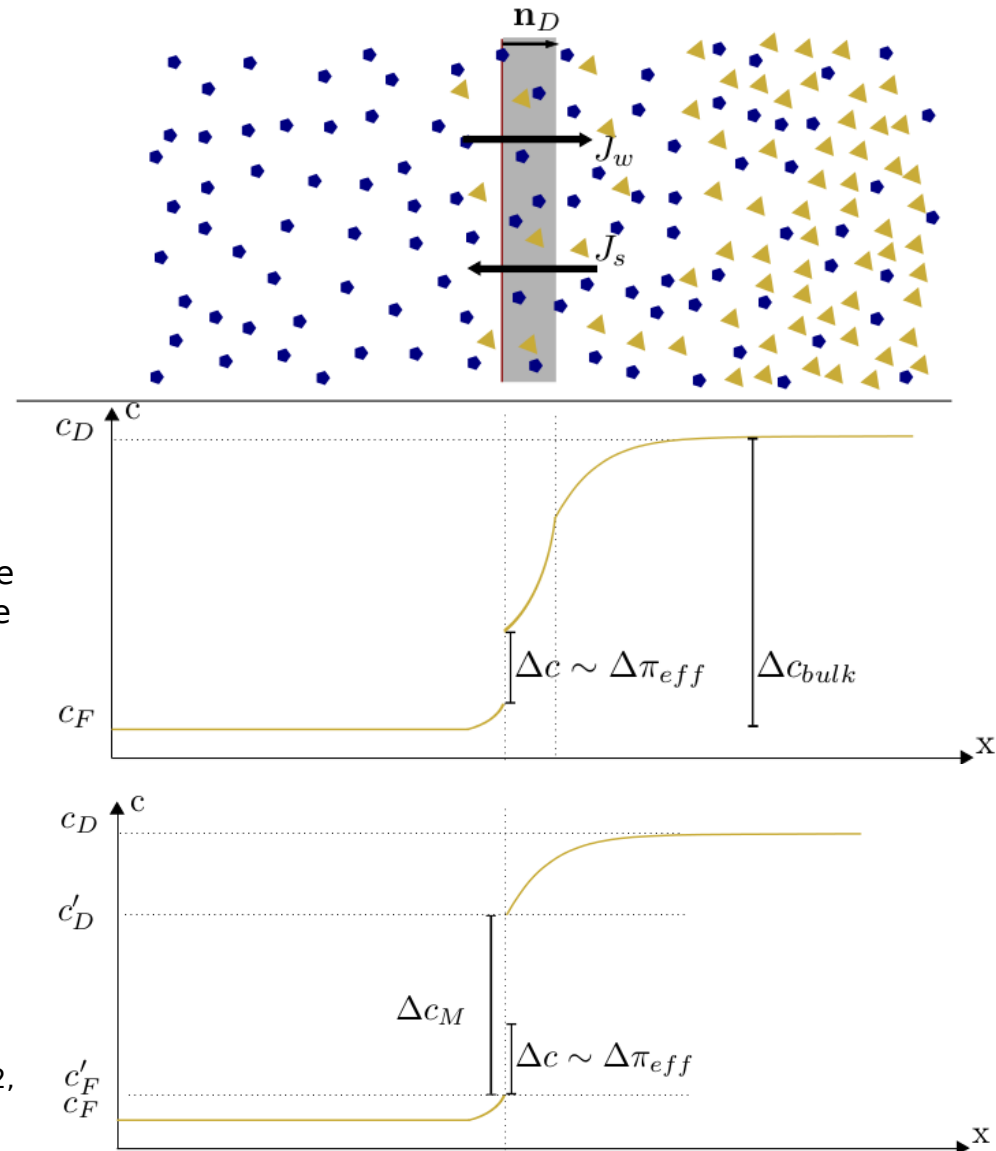
# The membraneFOAM algorithm

OpenFOAM algorithm resembling FO processes:

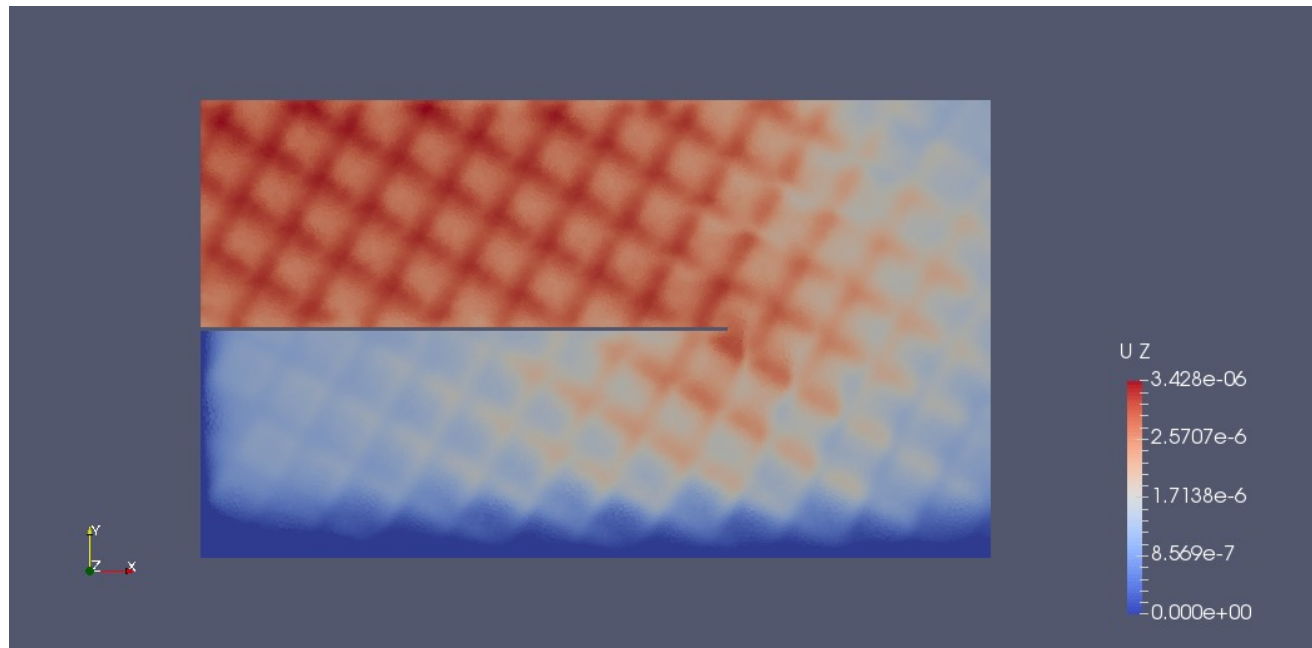
- Modelling ICP, depending only on A,B,K
- Evaluating the consequent water and reverse salt fluxes
- Developed in (1)
- Modification include applicability to bent membrane surfaces and non-zero hydraulic pressure difference across membrane

$$\mathbf{J}_w = A \left[ \frac{\pi_F |\mathbf{J}_w| \left[ \frac{c_D}{c_F} - \exp(|\mathbf{J}_w| K) \right]}{(|\mathbf{J}_w| + B) \exp(|\mathbf{J}_w| K) - B} - \Delta p \right] \mathbf{n}_D$$

(1) Gruber et al. Journal of Membrane Science, Vol. 379, No. 1-2, 2011, p. 488-495



# Mapping the water flux - optimization of spacer and baffle geometry



The water flux map allows to spot zones of severe ECP:

- When the optimal spacer and baffle geometry is found, the optimization process is brought to the pressure optimization and the number of envelopes.

# Thank you for your attention!

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Acknowledgements: MEMENTO, DHI, Aquaporin A/S



## In the near future:

- Baffle design
- Curvature influence
- PRO-SWM

# Bullet points

- Motivation
- What we do
- Spacer optimization
- Envelop sheets
- FO SWM
- 

